When roasted, the modified coffee beans exhibit improved tasting notes and a decreased amount of undesirable compounds.
A process for preparing modified green coffee beans for roasting

Field of the invention

The present invention relates to a process for preparation of modified green coffee beans for roasting as well as such modified green coffee beans.

Background

Coffee is one of the most popular beverages for humans. Before a cup of coffee can be brewed a variety of process steps have been performed. As a first step the berries or cherries are picked from the coffee plant. The berries may subsequently be sorted to produce different qualities.

Conventionally, the sorted cherries are then processed either by a dry processing or a wet processing. Dry processing involves e.g. drying the cherries in the sun, then removing the pulp, parchment and dried skin. This can take up to two weeks and the beans must be continuously raked to prevent mildew. Wet processing involves putting the cherries in water; any ones that float are removed as defective. The cherries are then pressed by a machine which only allows the seed and some pulp to pass through the holes. The remaining pulp is removed leaving the green beans, which are then left to dry leaving about 10 - 12 percent moisture content.

After the dry or wet processing, machines are used in a hulling process to remove the parchment layer from the wet processed coffee beans. The dry process involves removing the entire dried husk of the dried cherries. A polishing machine may optionally be used to remove any silver skin that is left on the surface after the hulling process. The beans are now referred to as green beans and are ready for further processing. The waste majority of the green beans are exported and processed close to the final consumer. Worldwide, approximately nine million tons of green coffee beans are produced each year.

The production of coffee beverages converts only the bean of the coffee plant into a valuable product. The pulp from the coffee cherry may be
discarded or processed to a product of a value less than the green coffee beans.

While all green coffee beans are processed, the method that is used varies and can have a significant effect on the flavor of roasted and brewed coffee. The green coffee beans are relatively stable and are transported from the coffee-producing countries to roasting, processing, or consumption all over the world.

The roasting of the green coffee beans transforms the chemical and physical properties of the green coffee beans into roasted coffee beans. The roasting process is what produces the characteristic flavor and aroma of coffee. In the same process the coffee beans expand and change in color and density.

A commonly used roasting plant in the industry is rotating cylinders containing the green beans and hot combustion gases. When the bean temperature reaches typically 165-200°C the roasting begins, accompanied by a popping sound similar to that produced by popcorn. These batch cylinders take about 8-15 min to complete the roasting depending on the initial moisture and the desired final color and degree of roasting. Coffee roasting using a fluidized bed is also commonly used.

The roasted beans are then ground to enhance extraction with water. Grinding reduces the particle size of the beans to 0.2-5.0 mm depending on the extraction process. Traditionally, roasted beans are ground by dry milling. The dry milling results in the escape of a characteristic odor, which reflects the escape of aroma components from the roasted coffee beans.

In the prior art it has been suggested to use sugars or amino acids for increasing the aroma both when added before the roasting process as well as in an intermediate step in the roasting procedure. One example is disclosed in GB2500662, which describes the use of sugar optionally together with aromatic substances in connection with green beans to enhance the flavor of the coffee after the roasting process.

Others have used the roasted coffee cherry and pulp and added them in various steps in the process as a flavor enhancing or maintaining means for coffee. Thus, US2008038437 describes adding of dried pulp
and/or husk of the coffee cherry to the roasted coffee beans.

It is the object of the present invention to suggest a process for preparing modified green beans which, when roasted, exhibit a perceived higher coffee drinking experience using predominately substances non-foreign to the coffee plant. A coffee product not treated with synthetic substances in any significant amount may be regarded by the consumer as a more appealing and healthy product. Furthermore, it is the object of the present invention to use components from the coffee production previously considered of low value and even a disposal problem. Thus, the ecological footprint may be smaller using the process according to the invention.

**Summary of the invention**

The present invention relates to a process for preparing a modified green coffee bean for roasting, comprising the steps of:

a) Providing a liquid coffee berry pulp or a liquid extract thereof and green beans from coffee berries,

b) Contacting the green beans with the liquid coffee berry pulp or the liquid extract thereof, and

c) Drying the modified green beans.

Surprisingly experiments have shown that the taste of the coffee beverage can be improved by contacting the green coffee beans with a liquid coffee berry pulp or a liquid extract thereof. It is presently believed that the chemical components in the coffee berry pulp or the extract thereof are absorbed by the green beans. When the modified green coffee bean subsequently is roasted it is presently believed that the chemical components are reacted either with themselves, with other components emanating from the coffee berry pulp, or with chemical components of the green bean. Irrespective of the theoretical explanation, the result of the roasting is the production of aroma components known to enhance the sensoric drinking experience and/or the reduction of aroma components known to be less pleasant.

In the art it is known to treat the green beans by a process referred to as decaffeination. According to a certain embodiment of the invention, green beans and/or the liquid coffee berry pulp or the liquid extract thereof
has been pretreated by decaffeination prior to step a). The pre-treatment reduces the concentration of caffeine in the resulting coffee beverage.

Other pre-treatment methods known in the art are included in the present application as well. Specifically, a pre-treatment in which the green beans has been pretreated by steaming prior to step a).

The aroma component precursors of the coffee berry pulp or the extract thereof may be transferred to the green coffee beans in a number of ways, including mass exchange during boiling, application of vacuum, osmosis, etc. According to a preferred aspect of the invention, the green coffee beans are initially dried to reduce the amount of free water. When the dried green coffee beans subsequently are contacted with the liquid coffee berry pulp or an extract thereof, the liquid containing components from the coffee berry pulp will be absorbed in the green coffee beans to produce modified green coffee beans. In a certain aspect, green coffee beans have a residual moisture content of 20% by weight or less before the contacting step b), preferably of about 15% by weight or less, more preferably of about 10% by weight or less and most preferably of about 7% by weight or less.

The green beans and the coffee berry pulp used in the present invention may be obtained from any species of the coffee plant, including the species of Robusta (Robusta), Arabica (Arabica), Coffea liberia, C. excelsa, C. stenophylla, C. mauritiana and C. racemosa. The world production is dominated by the varieties Robusta and Arabica. In a certain aspect of the invention, the liquid coffee berry pulp or a liquid extract thereof and the green beans provided in step a) emanate in whole or in part from different coffee plant species.

In another aspect of the invention the coffee berry pulp or an extract thereof and the green beans provided in step a) emanates from the same coffee plant species.

Especially, when the modified green coffee beans are produced close to the site at which the coffee beans are harvested, there may be a shortage of supply of a different species which favors the use of coffee bean pulp and green beans from the same coffee plant species.

Within each species several varieties exist. The Coffea Arabica va-

Robusta varieties include Kouilou, Luweno, Kisansa, and Nganga.

Interspecific varieties include Uganda, Timor Arabusta, and Sarchimor.

The present invention includes that, the liquid coffee berry pulp or a liquid extract thereof and/or the green beans are from different varieties within the same species. Also included in the present invention is the use of a blend of different varieties from different species.

Coffee beans from Arabica are said to produce higher-quality coffee beverages compared to other commercially grown coffee species, such as Robusta, which is typically used for lower-quality coffee mixtures of Robusta varieties and/or Arabica varieties. Nevertheless, Robusta coffee species are usually easier to grow than Arabica species and typically allow for a greater amount of ripe coffee berries to be harvested, when compared to the other major coffee species. Therefore, Robusta coffees are usually cheaper to produce and consequently there is a major commercial interest to increase the quality of green coffee beans obtained from the coffee species Robusta. An increasing part of the world coffee production is Robusta. In 2013, 40% of the world coffee production was of the Robusta species. Thus, according to a preferred embodiment of the invention the green beans emanate from the coffee plant species Coffea canephora (Robusta).

The coffee berry pulp comprises fresh fruit pulp obtained by separating the green coffee bean from the coffee berries, or dried fruit pulp, which has subsequently been reconstituted with water.

If the fresh coffee berries pulp is used directly in the process of the present invention, the liquid may be obtained by comminuting the fresh coffee berry pulp to a purée or pressing the fresh coffee berries to a juice. The
fresh coffee berries pulp decomposes rapidly due to e.g. fermentation by microorganisms. Unless the fresh coffee berries pulp is used shortly after the production it is necessary to preserve the fresh pulp.

A preferred way of preserving the pulp is by drying. The drying may be performed by the sun or any suitable mechanical solution, including drum-, fluid bed-, freeze-, pneumatic- or spray drying. During, before or after the drying, the pulp may be comminuted to obtain finely divided dry pulp. According to a certain method whole berries are dried, such as by freeze drying, before significant fermentation has occurred.

The liquid coffee berry pulp may be obtained by suitable addition of a solvent or process aid to the dried coffee berry pulp. The solvent may be added to the dried coffee berry pulp in any amount needed to obtain the desired concentration. In the alternative, a juice is pressed from the fresh berries, which optionally may be concentrated or supplied with additional water prior to use in accordance with the present invention.

In a preferred aspect of the invention an extract of the coffee berry pulp is prepared by

i. treating the coffee berry pulp at elevated temperature,

ii. separating the solid part of the coffee berry pulp, and

iii. recovering an aqueous extract.

The preparation of an extract ensures that less solid and insoluble particles are present on the surface and in the pores of the green beans after. Thus, a better absorption of the extract may be obtained and less surface material is to be removed prior to roasting. Furthermore, the treatment at elevated temperature provides for an at least partly decomposition of the plant material, which will liberate more of the desired components in the coffee berry pulp.

Preferably, a solvent, such as water or ethanol, is added at step i. The solvent assists in adjusting the concentration of dry matter in the extract. In the event the extract is required to be with a higher dry matter content, excess solvent may be removed by well-know concentration methods, including reverse osmosis, nanofiltration, ultrafiltration, centrifuging, evaporation, etc.
In a preferred aspect the coffee berry pulp is heated to a temperature of between 50°C and the boiling point of the coffee berry pulp. In a more preferred embodiment, the temperature is above 60°C, such as 70°C or above. Temperatures at these value ranges tend to soften and decompose the plant cells, especially during extended treatment. In an aspect of the invention, the coffee berry pulp is treated at elevated temperature for 5 min or more, such as 10 min, 15 min, 20 min, or more.

Usually, the coffee berry pulp is not heated to its boiling point to avoid decomposition of valuable components. Thus, in a preferred embodiment, the coffee berry pulp is heated to a temperature of 5°C or more below the boiling point of the coffee berry pulp.

The coffee berries contain various polysaccharides, which are undesired in the extract. Examples of such polysaccharides include pulanan and pectin causing a high viscosity. In a certain embodiment, the amount of undesired polysaccharides is reduced to increase the processability. One way of reducing the amount of pulanan or pectin is to treat the extract with a suitable enzyme, such as pulanase or pectinase. Other types of enzymes, which may be employed include, but are not limited to, amylase, mannanase, hemicellulase, glucanase, cellulase, esterase, protease, cellobiase, arabinase, galactanase, arabinogalactanase, nuclease, isomerase, ligninase, and lipase. In a preferred aspect of the invention, the extract is refined to at least partly decompose or remove pectin.

The amount of soluble dry matter in the extract may be adjusted in accordance with the specific process. On the one hand the amount of dry matter should be high enough for an effective process to occur not requiring excessive subsequent drying. On the other hand the viscosity should not be too high, which will inhibit the absorption of the soluble dry matter in the green beans. Usually, the amount of soluble dry matter in the extract is 2% by weight or more. In certain embodiments of the invention, further compounds may be included in the extract. Such compounds include penetration enhancers like food grade surfactants to ease the absorption of the extract in the green beans.

To obtain a short process time the contacting between the liquid
coffee berry pulp or the extract thereof and the green beans are usually performed at an elevated temperature. Usually, the green beans are contacted with the liquid coffee berry pulp or the extract thereof at 40°C, or more.

The contacting time, residual moisture of the green beans and temperature are all parameters that influence the effectiveness of the present process. In accordance with a preferred aspect of the invention, the green beans are contacted for a time sufficient for the green beans to gain 10% by weight or more, such as 20% by weight, 30% by weight, 40% by weight, or more.

In some embodiments a layer of dry matter is deposited on the surface of the green beans. In the subsequent roasting process, the surface layer may contribute to less desirable taste notes, as the surface layer contains a high amount of carbohydrates, which burns or caramelises to provide the undesired taste. Therefore, it is preferred that the green beans after the contacting step b) are rinsed prior to the drying according to step c).

After the contacting step, the modified green beans are dried. The drying step results in a deposition of the soluble dry matter in the interior of the green bean. The drying may be conducted to various residual moisture contents. It is preferred that the contacted green beans of step b) is dried to a residual moisture of 20% by weight or less, such as 15% by weight, 10% by weight, 7% by weight or less. When dried to a residual moisture of 1-10% the modified coffee bean is generally able to be stored for months without substantial deterioration.

The green bean modified in accordance with the present invention has the potential to develop positive sensoric taste notes in the roasting process. Thus, for the production of roasted coffee beans, drying step c) is followed by d) roasting of the modified green beans to produce a roasted coffee bean. Subsequently, the roasted coffee bean is subjected to e) grinding to produce a roasted and ground coffee bean.

**Detailed description of the invention**

The present invention relates to a process for the modification of green coffee beans in order to improve the flavor and aromatic profile of
green coffee beans, when the green beans are roasted. Green coffee beans are used e.g. to produce ground coffee, coffee powder, coffee beverages and coffee-based food products. Green coffee beans possess the potential to develop during roasting the characteristic flavors of coffee by changing color, taste, smell and density. These roasted coffee beans may be used as primary products for the manufacturing of special sorts of coffee and may also be used as ingredients for the manufacturing of coffee-based food products.

Green coffee beans are obtained from the ripe coffee berries, which are produced by several species of the coffee plant *Coffea*. *Coffea* is a genus of flowering plants in the Rubiaceae family, which grow as small bushes or trees in tropical regions. The green beans and the coffee berry pulp may be obtained from any species of the coffee plant, including the species of Robusta (Robusta), Arabica (Arabica), Coffea liberia, *C*. stenophylla, *C*. mauritiana. *C*. racemosa and mixtures thereof, or are derived from interspecies crossing between any of said coffee species. Preferably, the green beans and the coffee berry pulp are obtained from the species of Robusta (Robusta), Arabica (Arabica) or mixtures thereof. In a preferred embodiment, the green bean is obtained from the species Robusta. Arabica is usually grown between 800 meter and 1500 meter above sea level, but can be also cultivated at heights between sea level and 2800 meter above sea level. Arabica can tolerate low temperatures, but not frost, and is optimally cultivated at temperatures around 20°C. Growing Robusta requires less intensive care, yields a higher amount of ripe coffee berries and is therefore cheaper to maintain compared to Arabica. Furthermore, Robusta has immunity or great resistance to the leaf rust by *hemileya*. Approximately 40% of the coffee produced in the world is Robusta.

The coffee berries ripen around eight months after the emergence of the flower by changing their color from green to red. Once ripe, the coffee berries are picked and processed in two ways: 1. Dry method. The berries are dried first and hulled afterwards, to obtain "pergamo" beans; or 2. Wet method. The husk is removed first to obtain the beans with pulp, which are then "washed" in water for 24 or 48 hours before drying to obtain the coffee...
beans. Both methods may be applied in the present invention.

The drying of the coffee beans or pergamino beans is typically performed outdoors by spreading the berries or beans on large concrete plates or on suitable netting, allowing for aeration, and drying them by exposure to sun radiation.

"Green" coffee beans according to the present invention refer to coffee beans, which have been extracted from harvested ripe coffee berries after removal of the pulp of the coffee berry. This may include coffee beans still being covered by a parchment coat, also referred to as the hull or the endocarp, and/or the silver skin, also referred to as testa or epidermis. The term "Green" coffee beans also covers coffee beans, which have been immersed in a fluid, dried, steamed, pre-germinated and/or fermented.

The term "germination" according to the present invention refers to the process in which the green coffee beans are treated under conditions such that a sprout of a coffee plant may emerge from a green coffee bean. Typically for germination to occur, external factors like temperature, water, oxygen and light have to be adjusted to be in optimal conditions, which are typically closely related to the ecological condition of the coffee plant's natural habitats.

The term "pre-germination" according to the present invention preferably refers to a process step wherein the reaction conditions are selected such that germination of the green coffee beans could occur. In another preferred embodiment, the time interval of said "pre-germination" step is selected to be in a range which is too small for germination to occur. This means that no seedling could emerge from the green coffee bean.

The rationale behind this embodiment of the invention is that during germination and/or pre-germination lots of biochemical modifications take place within the green coffee beans that may affect the aroma precursors in the coffee bean. For example, proteins could be hydrolyzed during germination and/or pre-germination and transformed into free amino acids. Such transformation would affect the Maillard reaction during roasting of beans that have been treated this way. Furthermore, bitter or astringent substances may be metabolized and therefore decrease the expression of such flavors.
in roasted beans, which could be obtained in this embodiment.

The fresh green coffee beans usually start germination 3 days to 7 days after having been brought into contact with humidity or liquid water. During the pre-germination process, coffee beans can be collected and dried appropriately at selective time intervals during the pre-germination period to evaluate the chemical and sensorial modifications in the green and roasted coffee beans by using adequate methodologies.

The separation of the extract from the solid components may be performed by any suitable device, including a centrifugal separator, membrane filtration, or belt filtration. A preferred centrifugal separator is a two phase decanter centrifuge. Suitable decanter centrifuges may be obtained from GEA Westfalia, etc.

Dried coffee beans possess the potential to develop special aromas and flavors after roasting. Both the Robusta and Arabica coffee species are of particular relevance, since they present different organoleptic traits. Arabic coffee beverages present a subtle mild aroma and relatively low caffeine content when compared to Robusta coffees. Robusta coffees have higher caffeine contents and a stronger body in taste.

The differences in their aromas make these two species suitable for the preparation of various kinds of coffee beverages. While Arabica coffee products are typically used for mild coffees, Robusta coffee products on the other hand are usually used as supplements for instant coffee.

It has now surprisingly been found that the aromatic profile of green coffee beans can be modified by contacting said coffee beans with the liquid coffee berry pulp or an extract thereof. It is thus an object of the present invention that the modification of green coffee beans improves the quality of the aroma of green coffee beans after roasting. The modification of the aroma may be manifold, as will be apparent from the present application. On the one hand, the aroma of the green coffee bean may be directly modified, e.g., by infiltration of flavor-modifying aromatic substances. On the other hand, the aroma of the roasted coffee bean may be modified by providing substances from the coffee berry pulp or an extract thereof in the green beans, which change the aroma of the roasted coffee bean. The present
application provides for a general process to modify the green coffee bean, resulting in a modified flavor or aroma of the green coffee bean, the roasted coffee bean, or the final product made from such beans.

The diffusion of flavor-modifying agents from the coffee pulp or the extract thereof into the green coffee beans during the contacting process modifies the chemical composition or proportion of substances in the green coffee beans. The green bean having absorbed substances from the coffee pulp or the extract thereof may in a roasting process develop modified ratios between the different aroma components. In a preferred embodiment, the amount of aroma components giving a positive sensoric experience is increased, whereas the amount of aroma components providing for a negative sensoric experience is decreased. While the individual taste of consumers varies a general consensus exist on some of the taste compounds. Compounds like guaiacol and ethyl guaiacol provide a flavor of smoked wood, which is not desirable. The present invention surprisingly decreases the amount of these undesirable compounds.

To increase the rate of absorption and distribution of substances from the coffee pulp or the extract thereof, the fluid is preferably in motion around the coffee beans during the contacting phase.

In a preferred embodiment, the liquid coffee berry pulp or the liquid extract contains a solvent, which can be selected from the group consisting of water, ethanol and a mixture thereof. In a further preferred embodiment the solvent is distilled water.

The chemical reactions during roasting are complex and not fully understood. It is assumed that during roasting of green coffee beans free amino acids could react with sugars, such as glucose and fructose, in the so-called Maillard reaction to form substances that are mainly perceived as positive aromatic substances by the consumers. However, as the examples of the present invention show, availability of sugars is not the only important chemical compound for a desirable taste to be developed during roasting, since green beans treated with a sugar solution only resulted in slight modification of the taste compared to the untreated brew. According to the literature both sugars, amino acids and chlorogenic acids take part in the for-
mation of aroma compounds. These three compounds are present in coffee berries and beans.

The modified green coffee beans may be roasted and ground according to known means. The green coffee beans are relatively stable and are transported from the coffee-producing countries to the consumers all over the world. At industrial sites the green coffee beans are processed to produce, whole roasted beans, ground roasted beans, extracts and/or instant soluble coffee. The modified green coffee beans are subjected to roasting, which transform the chemical and physical properties of the green coffee beans into roasted coffee beans. The roasting process is what produces the characteristic flavor and aroma of coffee. In the same process the coffee beans expand and change in color, and density. The coffee beans are usually roasted in an oven at temperatures between 240°C and 275°C for time periods ranging from about 3 to 30 minutes.

A commonly used roasting plant in the industry is rotating cylinders containing the green beans and hot combustion gases. When the bean temperature reaches typically 165-200°C the roasting begins, accompanied by a popping sound similar to that produced by popcorn. These batch cylinders take about 8-15 min to complete the roasting depending on the initial moisture and desired final color. Coffee roasting using a fluidized bed is also commonly used.

The roasted beans are then ground to enhance extraction with water. Grinding reduces the beans to 0.2-5.0 mm depending on the extraction process. Traditionally, roasted beans are ground by dry milling.

Examples

Example 1:
Preparation of coffee berry extract from wet material

A batch of freeze dried whole Arabica coffee berries of Brazilian origin (375 g) was treated with water (225 g) in a closed container until all water was absorbed. The berries were then de-pulped to give the coffee beans (285 g) still in their inner shell (parchment coat or endocarp) separat-
ed from the wet coffee berry pulp with outer skin (325 g). The latter was extracted with water (250 g) at 80°C for 30-60 minutes and decanted to give a viscous solution of 13.5 % (w/w) berry material. The solution was centrifuged at 4500 rpm for 4 minutes to remove insoluble particles. Fresh water (250 g) was added to the berry mass and heated to 80°C for 30-60 minutes to give a less concentrated extract. The extracts were mixed with water or with each other at different ratios to obtain solutions with different concentrations.

**Example 2:**

**Preparation of coffee berry extract from dry material**

A batch of freeze dried whole Arabica coffee berries of Brazilian origin (127 g) was cracked by hand and separated into green beans (74.5 g) and dry berry material (52.8 g). To the dry berry material was added water (500 g) and the mixture was heated to 80°C for 60 minutes and filtered. The filtrate was centrifuged at 4500 rpm for 4 minutes to remove insoluble particles. By this procedure 200 g of extract was obtained as a 4.8 % (w/w) solution of berry material.

**Example 3:**

**Treatment and roasting of green beans**

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were mixed with an aqueous solution of berry material (130 g, prepared as described in Example 2). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the modified green beans (372 g) were quickly rinsed with cold water (400 g) twice to remove residues on the surface. The wet green beans (411 g) were placed on a tray in an oven and dried at 40°C for 12-14 hours to a water content of 1%.

The beans were roasted in a Gene Cafe table roaster at set point
temperature 245°C with 3 minutes above 240°C before cooling. This resulted in a dark roast of the beans.

5 Example 4:
Treatment and roasting of green beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were mixed with an aqueous solution of berry material (125 g, prepared as described in Example 1 and diluted to a 6.5% dry solid content). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the green beans were flushed quickly under cold water to remove material on the surface. The green beans were placed on a tray in an oven and dried at 50°C for 1-3 hours to a total mass corresponding to the starting material (250 g) + absorbed material, and a residual moisture of 6%. The beans were roasted in a Gene Cafe table roaster at set point temperature 245°C with 3 minutes above 240°C before cooling.

Example 5:
Treatment and roasting of green beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were mixed with an aqueous solution of berry material (125 g, prepared as described in Example 1 with a 13.5% dry solid content). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the green beans were flushed quickly under cold water to remove surface material. The green beans were placed on a tray in an oven and dried at 50°C for 1-3 hours to a total mass corresponding to the starting material.
(250 g) + absorbed material, and a residual moisture of 6%. The beans were roasted in a Gene Cafe table roaster at set point temperature 245°C with 2 minutes above 240°C before cooling.

Example 6:
Treatment and roasting of green beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were dried in an oven for 2-3 hours at 50°C to a reduced weight (245 g). The dried beans were mixed with an aqueous solution of berry material (132 g, prepared as described in Example 1 with a 7.5% dry solid content). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the green beans (375 g) were flushed quickly under cold water to remove surface material. The green beans (404 g) were placed on a tray in an oven and dried at 50-60°C for 5-6 hours to a total mass corresponding to the starting material (250 g) + absorbed material, and a residual moisture of 6%. The beans were roasted in a Gene Cafe table roaster at set point temperature 240°C with 2.9 minutes above 235°C before cooling.

Example 7 (Comparative):
Treatment with sucrose and roasting of green beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were mixed with an aqueous solution of sucrose (112 g with a 7.1 g sucrose content). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the green beans were flushed quickly under cold water to remove surface material. The green beans were placed on a tray in an oven and dried at 50°C for 1-3 hours to a total mass corresponding to the starting material
(250 g) + absorbed material, and a residual moisture of 6%. The beans were roasted in a Gene Cafe table roaster at set point temperature 240°C with 4.2 minutes above 235°C before cooling.

Example 8 (Comparative):
Treatment with sucrose and roasting of green beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were mixed with an aqueous solution of sucrose (112 g with a 14.2 g sucrose content). The mixture was heated to 60°C for 6-8 hours in a soft plastic container and turned every 15 minutes to get a uniform contact between extract and beans. When all extract was absorbed, the green beans were flushed quickly under cold water to remove surface material.

The green beans were placed on a tray in an oven and dried at 50°C for 1-3 hours to a total mass corresponding to the starting material (250 g) + absorbed material, and a residual moisture of 6%. The beans were roasted in a Gene Cafe table roaster at set point temperature 240°C with 4.4 minutes above 235°C before cooling.
Example 9 (Comparative):
Roasting of untreated green Robusta beans

Green Robusta coffee beans of Vietnamese origin (250 g, 6% residual moisture) were roasted in a Gene Cafe table roaster at set point temperature 245°C with 3.2 minutes above 240°C before cooling.

Example 10:
Sensory analysis of coffee extracts

All the Robusta coffee samples described in Examples 3-8 were prepared from the same batch of green beans, as well as an untreated sample prepared as described in Example 9 for analytical comparison.

A coffee brew made from a commercially obtained, pure Arabica product was used for further analytical comparison.

All brews were made by the same procedure: Roast and ground coffee (15 g) was extracted with freshly boiled water (150 g) for 120 seconds and filtered to give a coffee extract subjected to sensory analysis (tasting) and GCMS analysis with special attention to specific aroma compounds.

GCMS analysis of coffee extracts

Gas chromatography-mass spectrometry (GCMS) is an analytical method that combines the features of gas-liquid chromatography and mass spectrometry to identify different substances within a test sample. Applications of GCMS include drug detection, fire investigation, environmental analysis, explosives investigation, and identification of unknown samples. Additionally, it can identify trace elements in materials that were previously thought to have disintegrated beyond identification. For our purpose GCMS has been used for detecting and monitoring important aroma compounds.

Samples of all brews were extracted with dichloromethane and a qualitative GCMS analysis was made of each extract, using a Shimadzu GCMS instrument. Suitable internal standards were added for quantification of the aroma compounds. The ppm quantities of selected aroma compounds
present in the coffee samples are shown in Table 1.

<table>
<thead>
<tr>
<th>Aroma compound</th>
<th>Tasting note</th>
<th>Robusta, untreated Ex. 9</th>
<th>Robusta, from Ex. 7</th>
<th>Robusta, from Ex. 8</th>
<th>Robusta, from Ex. 3</th>
<th>Robusta, from Ex. 6</th>
<th>Robusta, from x. 4</th>
<th>Robusta, from Ex. 5</th>
<th>Ara- bic product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butanoic acid</td>
<td>Cheesy, fruity at lower conc.</td>
<td>5,81</td>
<td>3,83</td>
<td>3,49</td>
<td>2,42</td>
<td>1,10</td>
<td>1,75</td>
<td>1,61</td>
<td>0,00</td>
</tr>
<tr>
<td>2-methyl Butanoic acid</td>
<td>Sweaty</td>
<td>1,39</td>
<td>0,82</td>
<td>1,74</td>
<td>3,63</td>
<td>0,00</td>
<td>9,11</td>
<td>8,80</td>
<td>9,31</td>
</tr>
<tr>
<td>Guaiacol (undesirable)</td>
<td>Smoked wood</td>
<td>17,05</td>
<td>6,80</td>
<td>10,26</td>
<td>59,32</td>
<td>21,68</td>
<td>12,28</td>
<td>11,03</td>
<td>1,89</td>
</tr>
<tr>
<td>Ethyl guaiacol (undesirable)</td>
<td>Smoked wood</td>
<td>8,53</td>
<td>2,89</td>
<td>3,97</td>
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Table 1: Amount of selected desirable and undesirable compounds in coffee samples (ppm).
The taste of the brews made from Robusta treated with extract of the coffee berry pulp is remarkably better than the brew of untreated Robusta, and analysis show that the content of several key aroma components develop in direction of Arabica levels when the Robusta beans are pre-treated as described in Example 4 and especially Example 5, and that the berry extract pre-treatment give results superior to pre-treatment with only sucrose as in Example 7 and 8.

Butanoic acid is not detected in the Arabica product, but in all the pre-treated brews the levels are lowered compared to the level of the untreated brew. The brews made from berry extract pre-treated beans showed levels closer to Arabica than brews from sucrose pre-treated beans.

2-methyl butanoic acid is one of the most important acids that contribute to coffee flavor, and its level in the best pre-treated brews is comparable to the levels in the Arabica brew. This was not observed in the analysis of the sucrose pre-treated brews.

The compounds guaiacol and ethyl guaiacol contribute with important notes of smoked wood, but too high levels are considered undesirable. Their amounts in coffee brews do not depend much on coffee varietal but mostly on the degree of roasting. Robusta beans are traditionally roasted darker than Arabica beans to increase the extraction yield and to eliminate certain other tasting notes that are generally perceived as unpleasant. Roasting the untreated Robusta beans too lightly resulted in unpleasant off flavors.

With the treatment presented here, the usual degree of Robusta roasts were first of all not necessary to obtain extraction yields equal to (or even slightly better than) usual extraction yields of untreated Robusta, and secondly, the treatment surprisingly eliminated the unpleasant off flavors known from untreated Robusta roasted to the same degree.

This allowed for a lighter degree of roast, and as a result, the levels of guaiacols were kept down in the final brews.

2,3-pentanedione is formed from sugar compounds during roasting of green beans. It is formed during roasting from sugar and contributes with a note of pleasant buttery freshness to ground coffee and coffee extracts. In
most examples reported here, the level of this compound was increased towards Arabica levels, and pre-treatment with berry extract generally gave the better results.

_Furfuryl thiol_ and furfuryl methyl sulfide are sulphur compounds with a note of freshly roast coffee at low concentrations. Their levels in Robusta are affected by the berry extract pre-treatment and develop in direction of Arabica levels in the most successful examples. Pre-treatment only with sucrose modified the levels slightly.

_Homofuraneol_ is considered a desirable aroma compound and contributes with a fruity note. The level of homofuraneol is enhanced by pre-treatment with sucrose but get much closer to Arabica levels by pre-treatment with berry extract.

_Furaneol_ is also a desirable aroma compound. It adds a strawberry note to the coffee brew and is much more present in Arabica than Robusta. Pre-treating Robusta with either sucrose or coffee berry extract increases the level towards Arabica. The levels closest to Arabica are found in brews of beans pre-treated with berry extract.

_Pyridine_ is associated to the bitterness of coffee and is formed from amino acids and sugars during roasting. The pyridine levels depend somewhat on roasting degree, and Table 1 shows that the levels move towards Arabica levels in most of the brews made as described in the examples.

_2-phenylethanol_ is a component adding a flowery note to the coffee. It was present in the Arabica brew but not found in the analysis of the untreated Robusta. Pre-treatment of Robusta beans with sucrose or coffee berry extract increased the levels in the final brews, and the highest increases were found in brews made from beans pre-treated with berry extract.

_Acetylpyrazine_ is considered a very positive aroma component with a pleasant note of roast popcorn. It is formed from sugar and amino acids during roasting. Robusta beans pre-treated with sucrose resulted in brews with a diminished level of acetylpyrazine, whereas treatment with berry extract gave an increase, in some cases even to levels higher than what was found in Arabica.

In conclusion, modification of the green Robusta beans as de-
scribed in Examples 3 and 6 resulted in significant improvements in the taste of the final brew, whereas treatment with sucrose as described in Example 7 and 8 only resulted in slight modifications of the taste compared to the untreated brew (Example 9).

Based on the sensory analysis made by a board of in-house tasters, the best taste of the final brew was obtained when the Robusta beans were treated with coffee berry extract as described in Examples 4-5. Surprisingly, the tastes of these brews were competitive to the taste of a brew made from pure roast and ground Arabica beans.
PATENT CLAIMS

1. A process for preparing modified green coffee beans for roasting, comprising the steps of:
   a) Providing a liquid coffee berry pulp or a liquid extract thereof and green beans from coffee berries,
   b) Contacting the green beans with the liquid coffee berry pulp or the liquid extract thereof, and
   c) Drying the modified green beans.

2. The process according to claim 1, wherein the green beans and/or
   the liquid coffee berry pulp or the liquid extract thereof has been pre- treated by decaffeination prior to step a).

3. The process according to claim 1 or 2, wherein the green beans
   have been pretreated by steaming prior to step a).

4. The process according to any of the preceding claims, wherein the
   green coffee beans have a residual moisture content of 20% by
   weight or less before the contacting step b), preferably of about 15%
   by weight or less, more preferably of about 10% by weight or less
   and most preferably of about 7% by weight or less.

5. The process according to any of the preceding claims, wherein the
   liquid coffee berry pulp or a liquid extract thereof and the green
   beans provided in step a) emanate from different coffee plant species.

6. The process according to any of the claims 1 to 4, wherein the coffee
   berry pulp or an extract thereof and the green beans provided in
   step a) emanates from the same coffee plant species.

7. The process according to claim 5 or 6, wherein the liquid coffee berry
   pulp or a liquid extract thereof and/or the green beans are from
   different varieties within the same species.

8. The process according to any of the proceedings claims, wherein
   the green beans emanate from the coffee plant species Coffea
   canephora (Robusta).

9. The process according to any of the preceding claims, wherein the
coffee berry pulp comprises fresh fruit pulp obtained by separating the green coffee bean from the coffee berries, or dried fruit pulp, which has subsequently been reconstituted with water.

10. The process according to any of the preceding claims, wherein an extract of the coffee berry pulp is prepared by
   i. treating the coffee berry pulp at elevated temperature,
   ii. separating the solid part of the coffee berry pulp, and
   iii. recovering an aqueous extract.

11. The process according to claim 10, wherein a solvent, such as water or ethanol, is added at step i.

12. The process according to claim 10 or 11, wherein the coffee berry pulp is heated to a temperature of between 50°C and the boiling point of the coffee berry pulp.

13. The process according to claim 12, wherein the coffee berry pulp is heated to a temperature of 5°C or more below the boiling point of the coffee berry pulp.

14. The process according to any of the claims 10 to 13, wherein the coffee berry pulp is treated at elevated temperature for 5 min or more, such as 10 min, 15 min, 20 min, or more.

15. The process according to any of the claims 10 to 14, wherein the amount of solid matter in the extract is adjusted by concentration or addition of solvent.

16. The process according to claim 15, wherein the extract is refined to at least partly decompose or remove pectin.

17. The process according to any of the preceding claims, wherein the amount of soluble dry matter in the extract is 2% by weight or more.

18. The process according to any of the preceding claims, wherein the extract further contains a food grade surfactant or additive.

19. The process according to any of the claims 1 to 18, wherein the green beans are contacted with the liquid coffee berry pulp or the extract thereof at 40°C, or more.

20. The process according to any of the preceding claims, wherein the green beans are contacted for a time sufficient for the green beans
to gain 10% by weight or more, such as 20% by weight, 30% by weight, 40% by weight, or more.

21. The process according to any of the preceding claims, wherein the green beans after the contacting step b) are rinsed prior to the drying according to step c).

22. The process according to any of the preceding claims, wherein the contacted green beans of step b) is dried to a residual moisture of 20% by weight or less, such as 15% by weight, 10% by weight, 7% by weight or less.

23. The process according to any one of the preceding claims, wherein the drying step c) is followed by
d) roasting of the modified green beans to produce a roasted coffee bean.

24. The process according to claim 24, wherein the roasted coffee bean is subjected to
e) grinding to produce a roasted and ground coffee bean.

25. Modified green coffee beans obtainable by the process according to any one of the claims 1 to 22.

26. Roasted coffee beans obtainable according to claim 23.

27. Roasted and ground coffee beans obtainable according to claim 24.

28. Coffee beverage obtainable by aqueous extraction of the roasted and ground coffee beans according to claim 27.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. A23F5/02

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols):

A23F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, FSTA

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents:

- **“A”** document defining the general state of the art which is not considered to be of particular relevance
- **“E”** earlier application or patent but published on or after the international filing date
- **“L”** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- **“O”** document referring to an oral disclosure, use, exhibition or other means
- **“P”** document published prior to the international filing date but later than the priority date claimed

**Date of the actual completion of the international search**

10 December 2014

**Date of mailing of the international search report**

12/01/2015

**Name and mailing address of the ISA/Authorized officer**

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- Tel. (+31-70) 340-2040
- Fax: (+31-70) 340-3016

Graham, Judith
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<td>DATABASE FSTA [Online] INTERNATIONAL FOOD INFORMATION SERVICE (I FIS), FRANKFURT-MAIN, DE; &quot;Modifying the aroma of green coffee beans.&quot; XP002733602, Database access number FS-2014-03-Hv7878 abstract</td>
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